METHOD TO ALLOCATE COMMODITY FLOW IN A MULTI-DIMENSIONAL COMMODITY FLOW NETWORK

FIELD OF THE INVENTION

This invention relates generally to network communications, and, more specifically, to determining maximum multi-commodity flow in a multi-dimensional data flow network.

BACKGROUND OF THE INVENTION

The distribution of data flow among multiple data paths between nodes in a communication network is an important consideration in the efficient operation of a communication network. When multiple data link paths exist between two network nodes, proper allocation of the data among the data paths reduces the potential of overloading a single data link or node, and increases the utilization of the network.

Figure 1 illustrates a typical network configuration containing three primary nodes: A 100, B 110 and C 120. Numerous intermediate nodes are interconnected between nodes the primary nodes. Data flowing between primary nodes A and B may be distributed so as to pass through any one of a group of intermediate nodes. For example, intermediate nodes D 130 and E 140 may be used to route data from node A 100 to node B 110. Similarly, intermediate nodes F 150, G 160 and H 170 may be used to route data from primary node A 100 to primary node C 120, and intermediate node I 180 may be used to route data from primary node C 120 to primary node B 110. Thus, data that must be transmitted from primary node A 100 to primary node B 110 may be allocated to various combinations of paths, such as A-E-B, A-D-B, A-D-E-B, A-E-D-B, A-C-B, A-F-

C-B, A-F-G-C-B, etc. These paths to which data may be allocated represent a single commodity flow.

Methods of determining the allocation of a commodity flow in a Point-to-Point network are known in the art. Usually, linear programming techniques are used to determine the allocation of data flow among various network data paths. For example, one such method which determines multi-commodity flow for a price distributed among the data links is disclosed by N. Garg and J. Konemann, in an article entitled "Faster and Simpler Algorithms for Multicommodity Flow and Other Fractional Packing Problems," Proceedings of the 39th Annual Symposium on Foundations of Comp. Science, pages 300-309, Palo Alto, CA, November 1998, IEEE. Methods for determining commodity flow, however, are typically computationally intensive, requiring significant time to compute and determine a single distribution allocation. Accordingly, there is a need to provide a method to quickly determine a new allocation distribution which can be readily adapted to a computer and which is particularly adapted to situations when parameters that influence data flow allocation are changeable.

SUMMARY OF THE INVENTION

This invention relates to a fast on-line data flow allocation method utilizing unique principles of the invention to efficiently determine the allocation of data flow among data paths, particularly, when a parameter that influences data flow allocation is changed dynamically. In an illustrative embodiment, at least one commodity flow sample point is determined and a continuous boundary is constructed through the sample points. The continuous boundary (hereafter characterized as Maximum [Revenue] Flow

Frontier or MFF) can be constructed off-line and may be used to determine new data flow allocations when a data flow allocation parameter changes. By developing a continuous boundary data flow, allocation parameters can be determine using a limited number of sample points. This reduces the allocation complexity, and permits efficient data flow allocation.

BRIEF DESCRIPTION OF THE DRAWINGS

The advantages, nature and various additional features of the invention will appear more fully upon consideration of the illustrative embodiments to be described in detail in connection with the accompanying drawings. In the drawings:

Figure 1 illustrates a typical network configuration having multiple data paths between primary and intermediate network nodes;

Figure 2 represents the variation of commodity flow through a network;

Figure 3 represents graphically a multi-commodity data flow in two-dimensions;

Figure 4 represents graphically the multi-commodity data flow of Figure 3 wherein additional sample points are used to derive a straight-line approximation;

Figure 5 represents graphically the multi-commodity flow of Figure 3 using additional sample points to further derive an approximate boundary in accordance with the principles of the invention;

Figure 6 represents a flow-chart of the processing steps in accordance with the principles of the invention; and

Figure 7 illustrates an exemplary application of the principles of the invention in determining multi-commodity flow through a network configuration.